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METHOD OF SUPPLYING OIL FROM A FLOATING PRODUCTION STRUCTURE TO AN OFFLOADING BUOY VIA A THERMALLY INSULATED FLEXIBLE TRANSFER DUCT

The invention relates to a method of supplying oil from a first floating structure to an offloading structure, comprising the steps of:
providing a flexible duct extending between the two structures at a water depth of between 50m and 500m, the duct comprising a flexible elastomeric material and having an internal diameter of at least 600 mm and a length of between 1500 and 3000 m, and providing at least one pump at the first structure and pumping the oil through the duct at a pressure between 5 bar and 30 bar and at a flow rate between 1000 and 50.000 m3/hr.

Such flexible ducts are known from WO 02/44607, in which a marine hose is described which may have a length of 2 km or more, extending between an oil rig, FPSO, TLP, SPAR or Semi submersible, and an offloading buoy, such as a catenary anchor leg mooring (CALM) buoy, at depths between 80 and 30 meters. The known hose consists of 12-meter elastomeric segments with an internal diameter of 600 mm having end coupling flanges. The known duct is applied as a bundle of parallel ducts for increased capacity.

Rigid steel pipes are also used for transfer of crude oil, and generally have a diameter of 24'' such that multiple ducts are used in parallel for obtaining sufficient capacity. The transfer pipes extending horizontally below water level between the floating structure and the offloading buoy are supported by floaters. Due to the weight of the steel pipes and their limited flexibility, these steel pipes are subject to metal fatigue.

When hydrocarbons, such as oils are transported through the known mid-water transfer pipes, heat loss through these pipes results in increased viscosity of the hydrocarbons and reduced flow capacity.

It hence is an object of the present invention to provide a method of transfer of hydrocarbons through a duct between two floating structures which can operate at reduced pumping pressures and allows efficient transfer of crude oil in relatively large volumes. It is another object of the present invention to provide a method of transfer of

hydrocarbons via a light weight duct, which is less subject to fatigue problems and which can be easily installed.

Hereto the method according to the invention is characterised by

- providing a single flexible duct, and
- providing a wall thickness of the duct such that at water temperatures between 2°C and 20°C, preferably between 2°C and 10°C, the oil comprises at the first structure an inlet temperature T_{in} and at the second structure an outlet temperature T_0 which is such that $T_{in} - T_0$ is smaller than or equal to 15°C, preferably smaller than 5°C.

By providing a single, large diameter duct, instead of a bundle of ducts, the surface area of the duct, and hence the resultant heat loss through the surface of the duct is reduced. By providing a sufficient wall thickness, for instance by providing a wall thickness of elastomeric material between 3 cm and 7 cm, or by providing an insulation layer around the duct such as a layer of polystyrene material of a thickness of between 2 cm and 10 cm, the heat loss through the duct is reduced and crude oil can be pumped at reduced and substantially constant viscosity, such as between 40 cP at 40°C and 8 cP at 50°C, at low pumping pressures.

Preferably the heat transfer coefficient of the mid depth transfer duct is between 0.1 and 0.5 W/mK. In particular at water temperatures of between 4°C and 10°C, the low eat transfer coefficient results in a reduced heat loss over the length of the transfer duct, and in a substantially constant, low viscosity of the crude oil over the whole length of the transfer duct.

In a preferred embodiment, the insulating material may comprise an insulating foam, having buoyancy, such that the transfer duct has for instance substantially neutral buoyancy.

A friction reducing liner may be included in the transfer duct, such a and Nitrile layer, to obtain reduced pumping pressures.

An embodiment of the method according to the present invention will be explained in detail with reference to the accompanying drawings. In the drawings:

Fig. 1 shows a schematic overview of a mid-water flexible transfer hose according to the present invention,

Fig. 2a-2d show different configurations of the transfer hose of the present invention, and

Fig. 3 shows a longitudinal cross section of a transfer hose of the present invention.

Fig. 1 shows a flexible mid depth transfer hose 1, which is deployed from a dynamically positioned supply vessel 2. The transfer hose 1 is connected to a CALM offloading buoy 3 via a pull-in wire 4, connected to a winch 5 on the buoy. By winding up the pull in wire 4 on the winch, a connector head 6 on flooded hose section 7 can be pulled in and locked in connector 8 at the bottom of the buoy 3. The flexible hose 1 has a length of between 1500m and 3000m and extends at a depth of between 50m and 500 m below water level 10. The end of the hose 1 at the side of the supply vessel 2 is connected to a floating structure 12, such as an FPSO, a TLD (Tension Leg Deck), SPAR or Semi-submersible such as shown if Figs. 2a-2d. On the floating structure 12, the hose 1 is connected to a pump unit 13, which is connected with an inlet duct 14 to a tank 15 or other oil supply source.

Fig. 2a shows a simple catenary configuration of the flexible hose 1, Fig. 2b a wave configuration, Fig. 2c a hybrid configuration with tensioning weights 16,17 and Fig. 2d a tethered configuration, in which the hose 1 is connected to the sea bed 17 via tethers 18.

Hydrocarbons, such as crude oil, are supplied to the offloading buoy 3 at a rate of for instance 50.000 barrels per hour and a pumping pressure of pump 13 of 18 bar. In the duct the oil temperature may be 40°C and its viscosity will be about 40 cP. The water temperature at a depth of 200 m will be about 140°C. The temperature isolation of the flexible hose 3, which may be formed of rubber, such as described in WO 02/44607, which application is incorporated herein by reference, is such that the temperature difference between the outlet temperature T_0 of the crude oil at the buoy 3 and the inlet temperature T_{in} of the oil at the floating structure 12 is not more than 15°C, preferably lower than 5°C. The inlet temperature T_{in} may be between 30°C and 70°C. The reduced heat loss results in a substantially constant viscosity over the length of the hose 3 and hence in improved hydrocarbon flow.

As is shown in Figs. 2a-2d, each time a single flexible hose 3 extends from the first floating structure 12 to the offloading buoy 3. Multiple offloading buoys 3 may be used, at different distances from the floating structure, each time a single large-diameter flexible hose according to the present invention extending from the floating structure to a respective offloading buoy.

As is shown in Fig. 3, the hose 3 may comprise an outer layer 20 of insulating rubber or polystyrene, of a thickness of at least 2 cm. Preferably the layer 20 is a

buoyant material. The hose 2 has a wall 21 for instance of steel-reinforced rubber of wall thickness of between 0.5 cm and 1.5 cm. The inner surface of the wall 21 may be provided with a liner of reduced friction characteristics, such as a liner of Nitrile material. The internal diameter Di of the hose 3 is between 500 mm and 800 mm, the external diameter De of the inner hose part is between 100 mm and 200 mm and the outer diameter D0 is between 600 mm and 1000 mm.